Randomized Controlled Trial of Single-Operator vs. Two-Operator Ultrasound Guidance for Internal Jugular Central Venous Cannulation

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Abstract

Objectives: Use of ultrasound guidance for central line placement generally requires two operators: one to hold the transducer and the other to guide the needle. The authors propose a single-operator technique and compare it with the two-operator technique for placement of internal jugular central lines.

Methods: This was a randomized clinical trial conducted from June to September 2004 in a U.S. urban teaching hospital. Enrollment packets were randomized to dynamic single operator (D1) and dynamic two operator (D2). The procedure was performed under ultrasound visualization in the transverse plane. The primary outcome measure was cannulation success. A complete Bayesian analysis using noninformative priors to estimate the probability of similarity of outcomes for D1 and D2 was performed. All variables are reported with 95% confidence intervals (CIs) where appropriate.

Results: Forty-four patients were enrolled from the emergency department and intensive care unit. Twenty-three patients were randomized to D1, and 21 to D2. Cannulation success was 96% (95% CI = 85% to 100%) for D1 and 95% (95% CI = 83% to 100%) for D2. There was a 90% probability that the success rates of these two groups differed by less than 10% of each other.

Conclusions: This one-person technique appears to be equivalent to the standard two-person technique for successful ultrasound-guided internal jugular central venous catheterization with respect to overall success.

Keywords: ultrasound, central venous cannulation, single operator

Obtaining central venous access is a crucial skill in emergency medicine, but body habitus and anatomy often thwart attempts. Finishing the procedure quickly becomes more important in the setting of emergency department overcrowding and increasing demands on emergency physicians’ time. Ultrasound-guided internal jugular (IJ) central line placement has been proven superior to anatomic landmark techniques, but an often-heard criticism is its presumed requirement for an additional person to operate the ultrasound machine and hold the probe. The majority of studies that mention the number of operators use two people. In our experience, after a brief learning period, it becomes easy to perform the procedure with one operator. Our objective was to prove that this technique is equivalent to the two-person technique for IJ cannulation success.

METHODS

Study Design
This was a randomized clinical trial. It was approved by the institutional review board, and written informed consent was obtained from each patient or his or her guardian.

Study Setting and Population
The trial was conducted from June to September 2004 in a U.S. urban teaching hospital. Study subjects were...
patients in the medical intensive care unit and emergency department who required IJ central lines.

Study Protocol
Enrollment packets were randomized to dynamic single operator (D1) and dynamic two operator (D2). A portable ultrasound machine with a 7.5-MHz linear array probe (Sonosite iLook25; Sonosite, Bothell, WA) was used. The procedure was performed under visualization in the transverse plane, perpendicular to the vessels. Longitudinal and oblique methods have been described, but we had trained ourselves in the transverse method and thus is what we studied. In the one-operator method, the ultrasound machine was placed on its stand or laid on the bed. The physician held the transducer in the nondominant hand and guided the 18-gauge introducer needle with the dominant hand. In the two-person method, a second person, guided by the operator, positioned the transducer.

Operators were three emergency medicine residents. Each had received one hour of didactics on vascular ultrasound and one hour of hands-on teaching on ultrasound for IJ central line placement. Each had placed a minimum of five supervised anatomic landmark–guided IJ central lines. Before enrolling patients in the study, they were required to place ten supervised D2 IJ central lines and ten supervised D1 IJ central lines. The least experienced operator had placed 30 central lines at the study outset; the most experienced had placed several hundred. Each operator placed a roughly equal number of lines in each study group. Patients were enrolled when emergency medicine or intensive care unit residents notified study investigators.

Outcome Measures
The primary outcome measure was cannulation success. Secondary measures were first-attempt success, number of attempts, time to placement, and complications.

Data Analysis
We used the method of Blackwelder to calculate sample size for tests of equivalence, with a test level of 0.05 and a power of 0.80, with both success rates predicted to be about 0.96 (based on previous results) and to detect a difference of at least 0.2. This calculation indicated that 21 patients would be required in each group. We used separate models, logistic or linear as the response variable, for each outcome with the group D1 or D2 as the predictor. A standard, noninformative prior was used for each regression model parameter estimate. We used Gibbs sampling to estimate the posterior distribution of each parameter; 10,000 simulations were performed in each model in R software using MCMCpack. A Bayesian analysis was used because in that framework, it is particularly easy to estimate functions of the regression parameters, as was done here to compare groups D1 and D2.

RESULTS
Forty-four patients were enrolled from the emergency department and intensive care unit; 23 were randomized to D1 and 21 to D2. There was one failure in each group for a cannulation success of 96% (95% confidence interval [CI] = 85% to 100%) for D1, and 95% (95% CI = 83% to 100%) for D2. From our model, we were able to estimate that there is a 90% chance that the success rates of groups D1 and D2 are within 10% of one another, that is, the probability that the absolute value of the difference of the success rate in D1 minus the success rate in D2 was less than 10% was 0.90. First-attempt success was 56% (95% CI = 36% to 75%) for D1, and 38% (95% CI = 20% to 60%) for D2. Here, the probability that the absolute value of the difference of the first-attempt success rate of D1 minus D2 was less than 10% was only 0.27, with D1 being superior. The mean number of attempts was 2.2 (95% CI = 1.5 to 3.0) for D1, and 2.4 (95% CI = 1.3 to 3.6) for D2. The mean time to placement was 130 seconds (95% CI = 57 to 203 seconds) for D1, and 180 seconds (95% CI = 70 to 290 seconds) for D2. Complications were limited to two arterial punctures in D1 and one arterial puncture in D2. See Table 1 for further statistical analysis.

DISCUSSION
Our data indicate a high probability that the one- and two-person methods for ultrasound-guided central venous cannulation of the IJ vein are equivalent in regard to success. A federal agency has recommended that all IJ central venous catheters be ultrasound guided, based on multiple meta-analyses showing its superiority to anatomic landmark–guided techniques. However, one criticism of the practicality of ultrasound for this purpose is the presumed requirement for more than one person to be involved.

We had been using the one-person technique out of necessity or convenience and found it as easy or easier than the two-person method, but we could find little evidence that it had been formally compared with two-person techniques. Only one study described using a mechanical swivel arm for the transducer to eliminate the need for a second operator. Needle guides attachable to transducers are commercially available (Site Rite; Bard Access Systems, Salt Lake City, UT). These would facilitate a single-operator technique, but we...
could find no studies comparing them with “free hand” methods with either one or two operators.

Our data are less clear regarding first-attempt success, number of attempts, and time to placement. This is because the data trended toward one-person technique superiority, making the two techniques less “similar” by Bayesian statistics. While the first-attempt success rate might seem low to experienced sonographers, we should state that the study protocol was strictly adhered to regarding what constituted an attempt. Any redirection of the needle, such as often happens immediately after puncturing the tough outer layers of the skin, was considered another attempt.

The complication rate was low, although there was one more arterial stick in the D1 group. We do not believe the one-person technique is inherently more prone to carotid puncture. A much larger study would be required to find any statistically significant difference in complication rates, if one exists. Three carotid punctures out of 43 procedures (7%) might seem high for ultrasound guidance. Our experience in a larger study found the carotid puncture rate to be about 2%.11 The higher rate in the present study might be due to selection bias. We were called only for line placement that was perceived to be difficult. In addition, the least experienced team member was responsible for two carotid punctures, although he demonstrated the expected level of proficiency at identifying and cannulating the IJ vein when supervised.

LIMITATIONS

We were not called for all central line placements during the study period, but we believe the virtually identical success rates in our two study groups bear out our primary hypothesis. Two of the operators were study investigators, which may have introduced a bias in favor of proving the hypothesis, but we could not exclude them because they are among a very small group of physicians at our center currently trained in both techniques for central line placement.

CONCLUSIONS

The one-person technique for successful ultrasound-guided IJ central venous catheterization appears to be equivalent to the two-person technique with respect to overall success.

References


